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The *Portico degli Dei Consenti* (Roman Forum). Archaeometric study of a late ancient colonnade made of "*Cipollino verde*" marble

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ABSTRACT. — The aim of this work was an archaeometric study of the «*Cipollino verde*» marble of the grooved columns which, in about 367 A.D. were re-used to build the *Portico degli Dei Consenti* in the Roman Forum. Seven out of eleven fragments were sampled from in situ columns raised from the ground during the 19th century on occasion of Visconti's restoration after their Mediaeval collapse, during which five columns were replaced by travertine ones. The other four fragments were sampled from other pieces lying near the colonnade.

During the Roman Empire, «*Cipollino verde*» marble was widely used to decorate many buildings. Today, one archaeological problem is to verify whether this marble came exclusively from the well-known Imperial quarries in southern Euboea (Greece), from Italian ones (Apuan Alps, Tuscany) or from several other sources in the Imperial provinces (Spain, Portugal, Serbia, Albania, Greece). In addition, for Euboea it is important to define in which sectors of this Greek region (western, eastern, central) quarrying was more highly developed, since further knowledge would enable us to reconstruct ancient organisation of labour, travel routes and ports of embarkation.

Help in solving these problems comes from study of the minero-petrographic, chemical and isotopic features of the «*Cipollino verde*» formations outcropping in the Mediterranean basin. Current knowledge about formations in southern Euboea and the Apuan Alps («*Cipollino Verde*») identifies several discriminating parameters.

On the basis of results obtained from the «*Cipollino verde*» columns of the *Portico degli Dei Consenti*, seven samples were ascribed to a formation outcropping in western Euboea (Styra sup. and/or Styra inf. sub-district) and one to the formation outcropping in the Arni sector (Apuan Alps). Data for the three remaining marble columns could not assigned, on the basis of the considered parameters, either to Euboean or Apuan Alps districts.

RIASSUNTO. — Il presente lavoro è finalizzato allo studio archeometrico del marmo «Cipollino verde» con cui furono realizzate le colonne a fusto rudentato che intorno al 367 d. C., dopo minuzioso restauro, furono reimpiegate nella realizzazione del Portico degli Dei Consenti del Foro romano. Degli 11 campioni analizzati, sette sono stati prelevati da colonne in posto rialzate nel XIX secolo in occasione del restauro Visconti dopo il crollo avvenuto nel Medioevo. Durante questo intervento, cinque colonne furono sostituite con altre di travertino. I restanti quattro campioni provengono da altrettanti fusti di colonne rinvenute a terra presso il colonnato.

Durante l'Impero romano il marmo «Cipollino verde» fu utilizzato per abbellire molti monumenti. Uno degli attuali problemi archeologici è costituito dalla pressante esigenza di conoscere se tale materiale provenisse esclusivamente dalle note cave imperiali dell'Eubea meridionale (Grecia), da cave italiane (Alpi Apuane, Toscana) o da quelle delle province dell'Impero (Spagna, Portogallo, Serbia, Albania, Grecia). Nell'ambito delle coltivazioni euboiche grande importanza assume, inoltre, la capacità di identificare in quali settori di questa

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regione (occidentale, centrale, orientale) fosse più sviluppata l'attività estrattiva. La conoscenza di tale dato permetterebbe, infatti, di ricostruire quale fosse, all'epoca, la logistica delle vie di trasporto e l'identificazione dei porti d'imbarco.

Un contributo alla risoluzione di queste tematiche deriva dallo studio dei caratteri minero-petrografici, chimici ed isotopici delle formazioni di «Cipollino verde» affioranti nel bacino del Mediterraneo. I risultati degli studi fino ad oggi effettuati sui cipollini dell'Eubea meridionale e su quelli italiani delle Alpi Apuane, hanno permesso di definire alcuni parametri discriminanti. Sulla base dei risultati ottenuti dallo studio delle colonne di «Cipollino verde» del Portico degli Dei Consenti del Foro Romano è stato possibile concludere che sette campioni sono ascrivibili alla formazione affiorante nell'Eubea occidentale (subdistretto di Styra superiore e/o Styra inferiore) ed uno alla formazione affiorante nel settore di Arni (Alpi Apuane). I dati relativi ai marmi di «Cipollino verde» delle restanti tre colonne non possono, in base ai parametri considerati, essere ascritti né ai distretti euboici né a quelli delle Alpi Apuane.

Key Words: *Portico degli Dei Consenti*, Roman colonnades, «*Cipollino verde*», archaeometry

Introduction

The aim of this work is to contribute to the archaeometrical study (original stone quarries) of a monument of late antiquity. Although the *Portico degli Dei Consenti* has been little studied, we do know the precise year of its dedication, and that it was wholly built with stone from elsewhere, very carefully chosen for both quality and craftmanship. The *Portico degli Dei Consenti* (Photo 1, Fig. 1) was first restored in 367 A.D. by Vettius Agorius Praetextatus, *Praefectus Urbis*, one of the most famous members of the late Roman aristocracy.

In the 4th-century works, the original plan was maintained, but all the architectural components remaining upright consisted of remnants chosen for their high quality and were accurately restored at the moment they were installed. Precious grooved columns in «*Cipollino verde*» marble were painstakingly restored by inserting a number of plugs, which were used to fill chips and fractures, and also to

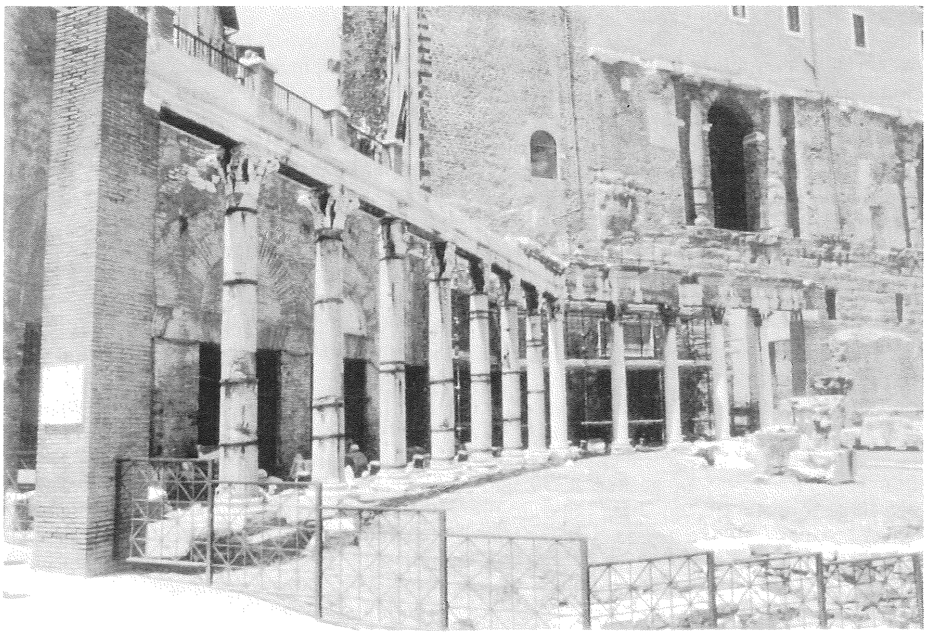

Photo 1 – *Portico degli Dei Consenti*. Overview.

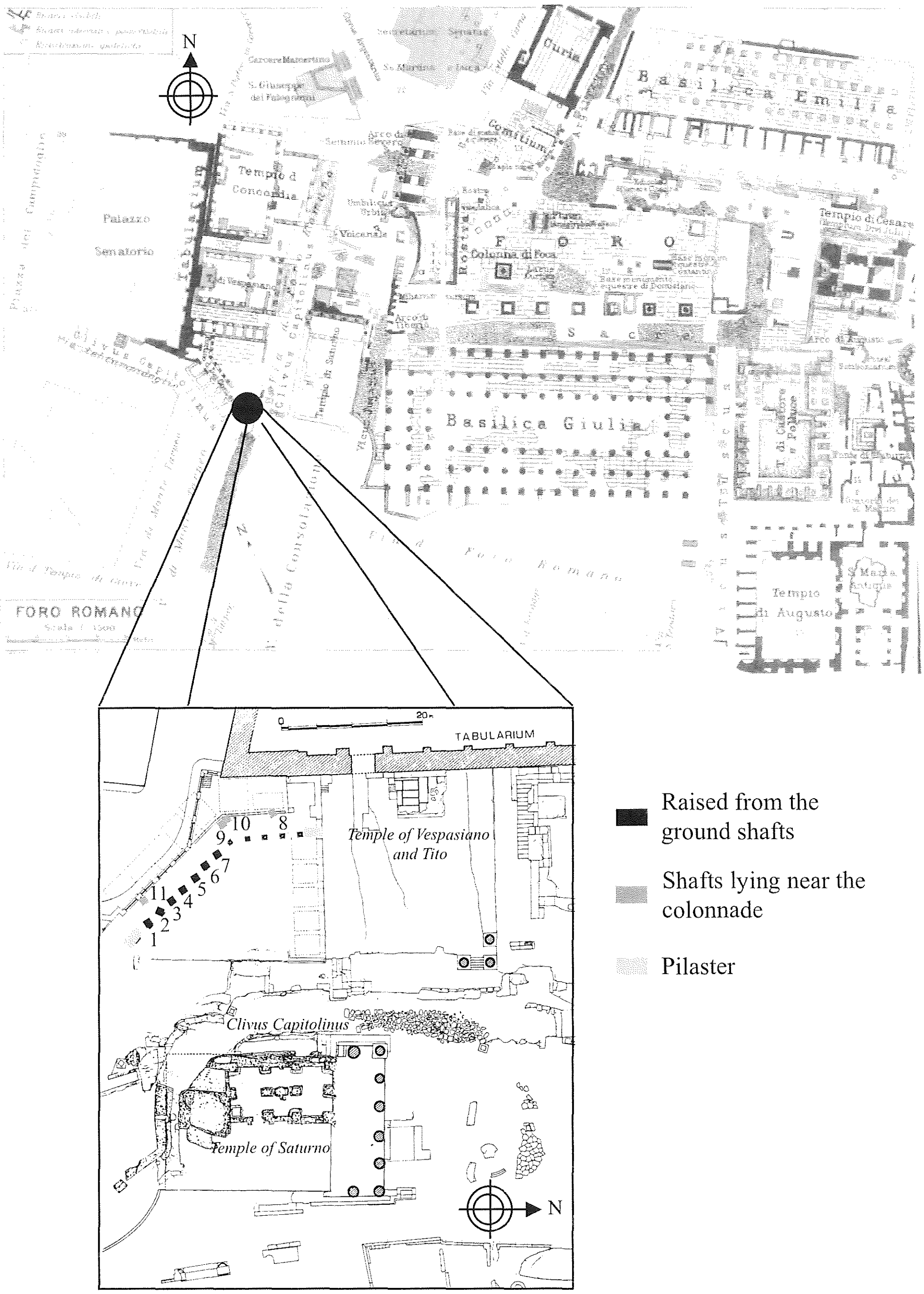

Fig. 1 – Roman Forum (Rome, Italy). Location of *Portico degli Dei Consenti* (after Pensabene, 1984, modified).

hide clamps, inserted to hold broken pieces together during restoration work. The capitals, all Corinthian and sculpted with trophies upon that occasion, were re-worked, to ensure a homogeneous aspect. The same treatment was applied to the bases.

Despite the fact that the trabeation of the Portico is the result of modern restoration, it was assembled with pieces of various provenance, sometimes even put together with square-angled joints.

Archaeometric tests were carried out on the columns, not only to determine whether their stone came from the same quarries, but also to establish a link between the dates of the shafts (1st-2nd centuries A.D.) and the specific quarries from which they were cut, thus demonstrating that those quarries were still worked at the moment when the columns were carved, or before this period, if the shafts were already stockpiled. As regards pieces raised from the ground, fragments were collected from the base of the shaft; shafts lying near the colonnade were sampled in their least weathered portions. In neither case was sampling carried out on parts added during restorations. Sampling was performed according to Doc. Normal 3/80. Analysed marble fragments come from seven columns lying in situ (C1-C7; Fig. 1; Photo 2) and four shafts lying near the colonnade (C8-C11; Fig. 1, Photo 3).

All samples were studied from minero-petrographic and geochemical points of view (fabric, texture, paragenesis, insoluble residue in wt%, chemical analyses, $\delta^{13}C$, $\delta^{18}O$, $^{87}Sr/^{86}Sr$).

In order to identify material provenance, results were compared with those of works on «*Cipollino verde*» marble found in some of the most important quarries worked in the Roman Imperial Age in the Mediterranean basin (Tucci, 1982; Lazzarini *et al.*, 1995, 1998; Masi *et al.*, 1995, 1997, 1999; Barbieri *et al.*, 1996; Negri Arnoldi *et al.*, 1999).

HISTORICAL DATA

The *Portico degli Dei Consenti* stands at the foot of the Capitol, in the westernmost extremity of the Roman Forum, west of the Temple of Saturn and of the building partially occupying it.

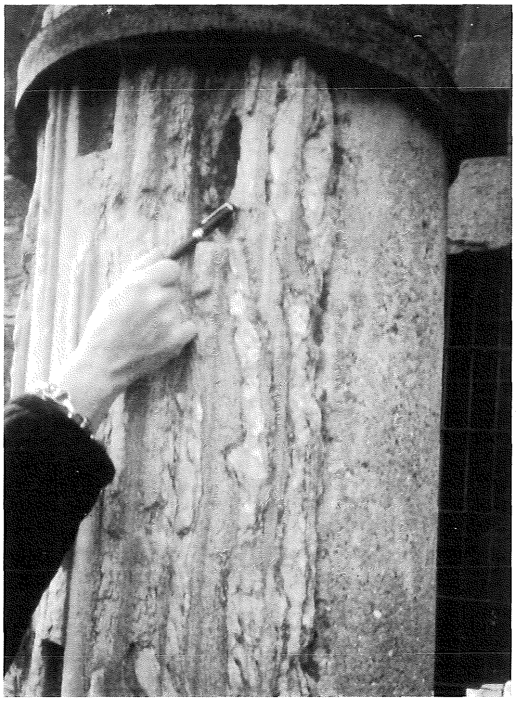

PHOTO 2 – *Portico degli Dei Consenti*. Column raised from ground; sampling point.

The area, filled by a deep layer of earth, was finally excavated in late 1833 and early 1834. After preliminary partial restoration between 1856 and 1858, the Portico, which in the meantime had been identified by Nibby (Nibby 1838; De Ruggiero, 1913), was partly reconstructed. New restoration works were carried out in 1942 by the architect Munoz, who added two columns and the pilaster in masonry now closing the south wing of the Portico, as well as the trabeation above (Nieddu, 1986).

The edifice, on two levels, consists of a series of rooms in *opera latericia* (originally lined with marble slabs) and a portico in front of them. The lower level is formed of a substructure in masonry with seven rooms. The

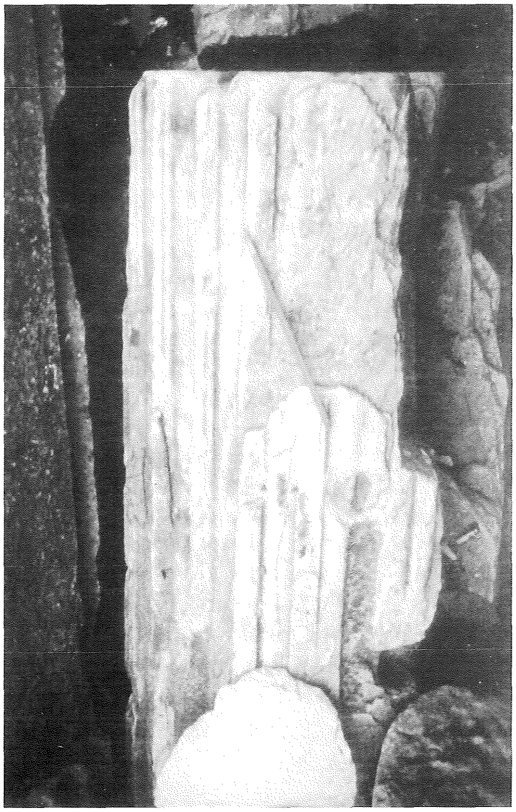

PHOTO 3 – *Portico degli Dei Consenti*. Shaft lying on ground; sampling point.

upper level has eight rooms, set along two sides of an obtuse angle, opening on to a corridor paved in travertine and closed by a portico with two wings along the same sides of the angle. The trapezoid shape of the front area, paved with marble slabs, is due to the presence of the bordering *Clivus Capitolinus* and the Temple of *Divus Vespasianus*.

The rooms in *opera latericia* are commonly dated to the Flavian age, when general re-design of the area was undertaken in order to accommodate the new Temple of Vespasian. More complicated is the dating of the portico: some authors date the original plan to the Flavian age on account of the style of the capitals and the ceiling of the architrave (Wegner, 1957; Mercklin, 1962); others to the Hadrian age (Pensabene, 1984; Nieddu, 1986). In both cases, however, dating is based on the conviction that the architectural elements re-used in Praetextatus's reconstruction belong to a preceding Imperial period. In any case, the area had been sacred since the Republican age. Lastly, the question arises regarding Praetextatus's work: whether it consisted of simple restoration of the pre-existing portico or whether he built a totally new edifice, using more ancient materials probably coming from different buildings, chosen because of their similarity. The latter possibility would also explain the differences between the capitals, in spite of their identical iconography (Pensabene, 1984; Nieddu, 1986). However, the dedicatory inscription, although largely integrated, indicates general re-planning of the whole sacred area and not only of replacement of the statues. The inscription quotes only the *praefectus urbis* and the *curator* (the consul Longeius) and not the emperors, perhaps because at that time the aristocracy was still mainly pagan and often opposed to Imperial rule.

The function of the edifice is related to the cult of the *Dei Consenti* and the display of their statues. However, the rooms in *opera latericia* (masonry) were probably used differently from those of the portico, perhaps as offices for the *Aerarium Saturni* (Pensabene, 1984).

The reconstruction is very close to the aspect that the portico would have had in the late 4th century, after Praetextatus's work, the exact nature and extent of which we know nothing.

The Portico itself consists of two wings of different length, placed at an obtuse angle (Pensabene, 1984; Nieddu, 1986), subdivided by twelve grooved columns (five of which, in travertine, have been considerably restored), with shafts in «*Cipollino verde*» marble (Mattern, 1995), Attic bases and figured Corinthian capitals (Mercklin, 1962) (four of which have been restored) (Photo 4).

A modern pilaster in masonry stands at each end of the colonnade. The trabeation, with three bands and a smooth frieze, is only partly

Photo 4 – *Portico degli Dei Consenti.* Detail of restored column shaft.

original. It is still possible to read part of the inscription (Photo 5) commemorating the re-introduction of statues for worship and probably of the building itself, by the *Praefectus Urbis* Vectius Agorius Praetextatus, supervised by Longeius (CIL VI, 102). A smooth cornice tops the trabeation.

Of the twelve columns of the Portico, only the seven in the south wing are ancient, the others in travertine marble being emplaced during the 19th-century restoration. Contemporary records indicate that the columns were already broken (Nibby, 1838) at the moment of their discovery.

During restoration between 1856 and 1858, and also visible in the 1860 drawing by C. Petri (Nieddu, 1986), five shafts were recomposed by re-assembling the drums of the columns which, on this occasion were also smoothed out (Photo 6). Two more columns were recomposed and raised in 1942 under the supervision of the architect Munoz, who added the brick pilaster at the southernmost edge of the Portico and also reconstructed a section of the architrave (Nieddu, 1986). At the same

Photo 5 – *Portico degli Dei Consenti.* Detail of dedicatory inscription.

time, further work was carried out on the 19th-century elevation of the Portico, the trabeation of which was first dismantled and then replaced at a height about 40 cm lower (Mercklin, 1962). There is no other evidence of this work.

The present state of the columns is therefore the result of a series of restoration works, the exactness and reliability of which must still be proven.

The columns have grooved shafts in «*Cipollino verde*» marble on Attic bases (Photo 1). The shafts, originally monolithic, were recomposed by superimposing drums of different heights. The grooves are filled out for their whole height (not only the lower third) by flat elements separated by wide listels, on which astragal rods slightly narrower than the listels were added (Photo 7). This double moulding borders the lower parts of the grooves and forms small arches near the upper and lower collars in the upper part. Small triangular leaves originate between the arches like spear points, lined up with the astragals separating the grooves.

This particular kind of grooved column is quite widespread. Recent studies describe over forty known cases of different marbles (Wegner, 1993; Mattern, 1995): the shafts of the *Portico degli Dei Consenti* fit type A of Mattern's classification, characterized by single grooves separated by small astragals and including most of the *Segmentstab-Kanneluren* columns (Mattern, 1995).

Almost all known examples belong to or come from urban edifices, e.g., the columns and pilasters of the exedra in the *Pantheon*, fragmentary shafts in «*Giallo antico*» in the peristylum of the *Domus Flavia,* seven others in the Stadium, and two fragments in «*Pavonazzetto*» and «*Giallo antico*» found in the cell of the Temple of *Venus Genitrix* and referred to Domitian's or Trajan's reconstructions (Mattern, 1995).

Photo 6 – *Portico degli Dei Consenti.* Shaft recomposed with overlapping drums of different height.

Photo 7 – *Portico degli Dei Consenti.* Grooves filled out by flat elements separated by wide listels.

Also worthy of mention are two fragmentary shafts in Caracalla's Baths (Mattern, 1995), and four columns in Portasanta discovered in the sacred area of Largo Argentina, where they had been re-used for a late reconstruction of the North Portico (Mattern, 1995). Not far from the *Portico degli dei Consenti* and still in the Forum area, is part of a pilaster of this type along the Via Sacra, north of the *Atrium Vestae*, and two monolithic shafts from the demolished church of St. Hadrian are still visible in the north-western corner of the Basilica Emilia (Mattern, 1995). Some other shafts, scattered and fragmentary, are now housed in museums or private collections, or were re-used in the city churches, e.g., St. Agnese.

Outside Rome, type B columns with *Segmentstab-Kanneluren* have been found at Ostia (Mattern, 1995); in a portico on the north side of the Forum at Terracina, perhaps identified with the *porticus post scaenam* of the theatre (lower collars in white marble; Mattern, 1995); in the rooms of Villa Adriana on the south-east side of the Piazza d'Oro (Mattern, 1995); and in the southern hall of the Gartenstadion (Mattern, 1995) (in the two latter cases, fragments in «*Pavonazzetto*»). There is also one column in Villa Spigarelli at Anzio, and another, re-used in the Castle of Subiaco (Mattern, 1995), both of which very probably belonged to Imperial villas in those areas (Mattern, 1995).

Preserved shafts, in coloured marble of various qualities, were very probably crafted in Rome, or at the *stationes marmorum* at Porto. The fact that they are all in one piece also strengthens the hypothesis that the shafts re-used in the *Portico degli Dei Consenti* were originally monolithic and that their present subdivision in sections of different heights is due to their reworking and restoration in late antiquity (see the analogous case of the columns of the nearby Temple of Saturn), and then again in modern times, when the drums were re-assembled and damaged surfaces were smoothed out.

Regarding chronology, it is commonly believed that these particular types of shafts were not used until the late Flavian age, and continued until the beginning of the the 3rd-century A.D. (Wegner, 1993; Mattern, 1995). It is more probable that the introduction of the «*Segmentstab-Kanneluren*» had already taken place in the Julian-Claudian age or perhaps even earlier, as indicated by the Subiaco column which, as already mentioned, may be assigned to Nero's villa, and perhaps also the one at Tivoli.

The Terracina columns may be even more ancient, set within the framework of the Augustan-Tiberian replanning of the Forum and adjacent areas.

We should not forget that some Renaissance drawings offer evidence of columns of this type within the cell of the Temple of *Mars Ultor*, greatly aiding chronology and perhaps influencing the spread of this refined type of shaft (Mattern, 1995). In any case, the type reached its widest dissemination between the Flavian and Hadrian ages, to which also the columns of the *Portico degli Dei Consenti* belong.

ANALYTICAL PROCEDURES

Petrographic, X-ray diffraction (XRD), X-ray fluorescence (XRF) and isotopic (C, O and Sr) analyses were carried out in order to characterise the collected samples.

XRD analyses were performed on insoluble residues. In this contest, mainly for phyllosilicate study, powders were oriented and then inserted in an automatic diffractometer (PHILIPS PW 1130/00, CuK_{α} radiation).

Major and trace element contents were determined by XRF (SIEMENS spectrometer, Cr anticathode tube).

The isotope ratios of the carbonate fraction were determined by mass spectrometry following a routine procedure (McCrea, 1950; Turi *et al.*, 1976). Results are reported against the PDB standard (Craig, 1957). Sr isotope ratios were measured on the carbonate fraction obtained by means of rapid dissolution in 2.5 N ultra-pure HCl. After centrifugation, the solution was passed through a cation exchange column, following standard procedures. Isotopic analyses were carried out on a VG-54E mass spectrometer; data acquisition and reduction was performed according to the procedure of Ludwig (1994). Repeated analyses on standards gave averages and errors (2σ) as follows: NBS 987, $^{87}Sr/^{86}Sr$=0.710262±15; $^{87}Sr/^{86}Sr$ normalised to 0.1194. Analytical uncertainty was ± 0.00005.

EXPERIMENTAL RESULTS

Petrography

Microscopically, all samples (except for some variations mainly related to the greater or lesser amounts of non-carbonate minerals, particularly mica and chlorite) are clearly calcareous in nature ($CaCO_3$: min.=71.62%, max =95.08%; Tab. 1). They show granuloblastic-heteroblastic (foliated lithotypes) to lepidoblastic fabric (banded lithotypes) and lineated fabric, evidenced by folded bands of phyllosilicates (Photos 8, 9).

Instead, samples C2, C4 and C8 have a whitish saccaroid structure in which sub-parallel greenish, sometimes slightly wavy, stripes are evident.

Paragenesis is composed of abundant calcite, occurring both in typomorph and overlapping in specimens, the latter clearly recognisable on albite and quartz relics, together with white mica and chlorite.

In samples C1 and C7, chlorite is greenish in colour, with deep green-yellow pleochroism. Very low interference colours are referred to Fe-members, as confirmed by X-ray diffraction analyses (2θ CuK_{α}=59.45°). Al-Mg-members are more frequent in the other samples, in which also quartz xenoblasts, almost always associated with albitic plagioclase, can be observed.

Samples C6 and C8 contain biotite and phengite, the latter only revealed

TABLE 1

Carbonatic fraction (wt%) and insoluble residue of samples from Portico degli Dei Consenti.

	% $CaCO_3$	Insoluble residue wt%
C1	71.62	28.34
C2	95.08	5.76
C3	87.96	12.66
C4	91.02	8.96
C5	87.41	12.76
C6	89.15	10.84
C7	81.26	18.73
C8	92.44	7.6
C9	83.25	16.75
C10	90.17	9.84
C11	88.42	11.57

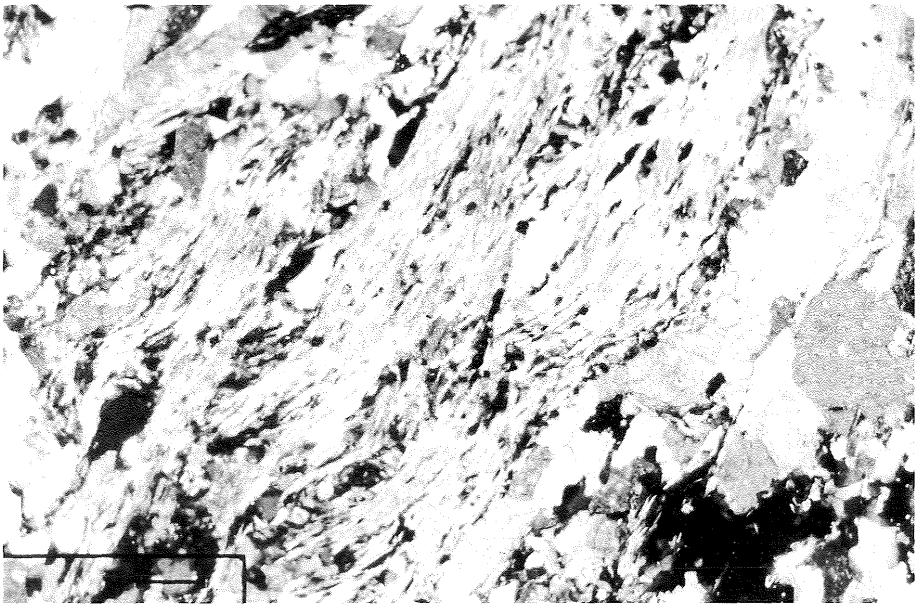

Photo 8 – Optical microscopy; plane-polarised; scale bar = 30 μm. Banded lithotype.

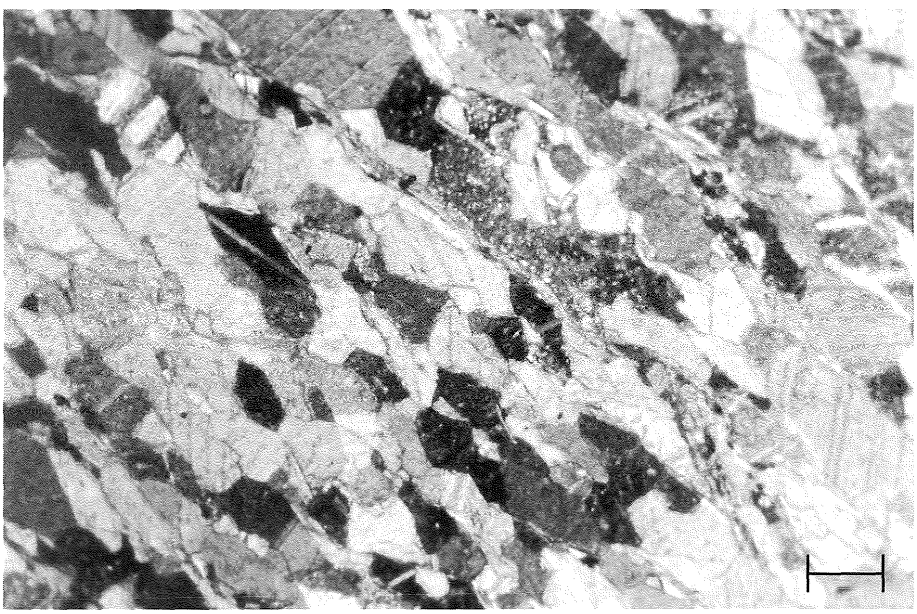

Photo 9 – Optical microscopy; cross-polarised; scale bar = 80 μm. Foliated lithotype.

diffractometrically (b_0=9.450±005 Å). Accessory minerals are apatite, Fe-oxides (ilmenite, magnetite), scarce zircon crystals, and clinozoesitic epidote.

All samples derive from regional dynamothermal metamorphism in the greenschist facies.

Geochemistry

Chemically (Tab. 2), on the basis of insoluble residues (Tab. 1), the samples roughly fall into two groups: i) high contents (10.84-28.34 wt%) and ii) low contents (5.76-8.96 wt%).

Samples C3, C4, C5, C7, C8, C11 and to a lesser extent, C1 (considering its hugh insoluble residue value) show the same variation trend defined by some significant element ratios (Table 3). This suggests that the marble derives from sedimentary rock belonging to a common geological environment.

Instead, samples C2, C6, C9, and C10 have some oxide and/or element ratios (P_2O_5, TiO_2, V, Zr, Cr, Y; Tab. 3) which are different and are not comparable with those already described. As these oxides and/or elements probably occur in minerals not involved in diagenesis, it is presumed that they were terrigenous products in the sedimentary basin.

TABLE 2

Major (wt%) and trace elements (ppm) contents of samples from Portico degli Dei Consenti. – = below detection limit (Fe_2O_3= Fe tot).*

	C1	**C2**	**C3**	**C4**	**C5**	**C6**	**C7**	**C8**	**C9**	**C10**	**C11**
SiO_2	17.03	4.20	6.77	5.11	8.68	4.84	11.01	4.13	9.96	4.97	6.69
TiO_2	0.23	0.03	0.06	0.05	0.08	0.18	0.11	0.05	0.12	0.08	0.07
Al_2O_3	5.83	0.66	2.48	1.63	2.48	2.05	3.29	1.50	3.15	1.99	2.36
$Fe_2O_3^*$	1.98	0.21	1.02	0.93	1.16	1.59	1.86	0.56	1.22	1.00	0.85
MnO	0.12	0.13	0.14	0.14	0.11	0.12	0.14	0.13	0.12	0.14	0.13
MgO	1.31	0.38	0.95	0.73	0.84	1.47	1.40	0.88	1.35	1.14	0.89
CaO	40.08	53.09	48.28	50.64	49.35	50.33	42.16	53.92	46.46	49.85	48.85
Na_2O	0.87	–	0.07	0.08	0.13	0.01	0.38	–	0.26	0.14	0.05
K_2O	0.93	0.10	0.48	0.25	0.28	0.54	0.48	0.30	0.52	0.32	0.48
P_2O_5	0.07	0.05	0.06	0.04	0.05	0.04	0.06	0.05	0.05	0.06	0.05
L.O.I	31.54	41.18	39.68	40.38	38.06	38.82	39.10	38.52	36.79	40.32	39.57
Tot	99.99	100.03	99.99	99.98	100.00	99.99	99.99	100.04	100.00	100.01	99.99
Rb	34	–	18	6	6	22	15	11	18	7	15
Sr	615	582	757	647	558	361	581	755	660	528	670
Y	22	11	10	10	5	17	20	12	8	14	9
Nb	3	2	–	–	4	4	2	–	–	2	–
Zr	37	–	9	2	8	31	10	3	11	3	6
Cr	81	37	41	38	45	46	62	42	49	70	41
Ni	61	14	33	27	45	22	65	27	26	84	30
Ba	212	73	126	61	99	73	115	104	251	157	146
La	23	10	3	9	2	4	12	12	1	12	8
Ce	18	–	–	–	–	2	–	–	–	–	–
V	47	11	15	16	24	30	34	12	35	16	23

TABLE 3

Elementary ratios of 11 samples from Portico degli Dei Consenti (Fe_2O_3= Fe tot).*

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11
SiO_2/Al_2O_3	2.92	6.36	2.73	3.13	3.50	2.36	3.35	2.75	3.16	2.50	2.83
Fe_2O_3*/MnO	16.50	1.62	7.29	6.64	10.55	13.25	13.29	4.31	10.17	7.14	6.54
Fe_2O_3*/TiO_2	8.61	7.00	17.00	18.60	14.50	8.83	16.91	11.20	10.17	12.50	12.14
TiO_2/MnO	1.92	0.23	0.43	0.36	0.73	1.50	0.60	0.38	1.00	0.57	0.54
TiO_2/P_2O5	3.29	0.60	1.00	1.25	1.60	4.50	1.83	1.00	2.40	1.33	1.40
La/Y	1.05	0.91	0.30	0.90	0.40	0.24	0.60	1.00	0.13	0.86	
Zr/Cr	0.46		0.22	0.05	0.18	0.67	0.16	0.07	0.22	0.04	0.15
Cr/V	1.72	3.36	2.73	2.38	1.88	1.53	1.82	3.50	1.40	4.38	1.78
Cr/Y	3.68	3.36	4.10	3.80	9.00	2.71	3.10	3.50	6.13	4.50	4.56
Y/Zr	0.59		1.11	5.00	0.63	0.55	2.00	4.00	0.73	4.67	1.50
Ni/Cr	0.75	0.38	0.80	0.71	1.00	0.48	1.05	0.64	0.53	1.20	0.73
Ni/V	1.30	1.27	2.20	1.69	1.88	0.73	1.91	2.25	0.74	5.25	1.30

The above data may be interpreted as indicative of different geological environment of sedimentary precursors.

The whole chemical data-set is confirmed, by C, O and in particular Sr isotopic ratio values (Tab. 4).

TABLE 4

Carbon, oxygen and strontium isotopic compositions of 11 samples from Portico degli Dei Consenti.

	$\delta^{13}C$ (PDB)	$\delta^{18}O$ (PDB)	$^{87}Sr/^{86}Sr$
C1	2.09	-2.95	0.70776
C2	2.36	-6.52	0.70752
C3	2.23	-4.56	0.70775
C4	2.41	-2.90	0.70776
C5	2.27	-2.76	0.70779
C6	1.60	-5.90	0.70800
C7	2.33	-3.17	0.70779
C8	2.36	-2.81	0.70778
C9	2.19	-3.33	0.70798
C10	2.57	-3.07	0.70811
C11	2.24	-3.14	0.70779

COMPARISON BETWEEN «CIPOLLINO VERDE» MARBLE AND ITALIAN AND GREEK SAMPLES

From both petrogenetic (Triassic marble, regional dynamo-thermal, greenschist facies and a more or less marly marine calcareous precursor) and minero-petrographic points of view, and from the contents of oxides and trace elements (except for the occurrence of dolomite, found only in the Apuan marble; Tucci 1982; Lazzarini *et al.* 1995; Barbieri *et al.*, 1996; Negri Arnoldi *et al.*, 1999), there is no great difference between «*Cipollino verde*» marble of Italian (Apuan Alps) or Greek (Euboea) origin. Both show the same paragenesis; saccaroid to granoblastic-lepidoblastic fabric; from isotropic to slightly oriented texture, up to strongly schistose, foliated and banded with accentuated folds and sometimes pleated.

Recent studies (e.g., Negri Arnoldi *et al.*, 1999) have identified some discriminating chemical parameters such as the Al_2O_3/Y isotope ratio (considering the heterogeneity of the weight percentage in the non-carbonate fraction, values were normalised to a 5 wt% content of insoluble residue, in order to compare element contents) and, limited to some sectors, C and O isotopic ratios. However, some minero-petrographic and chemical features become significant in distinguishing the various sectors of each district. In some cases, relics can be attributed not only to a certain geographical area, but even to a single sector.

The Apuan sectors of Arni, Isola Santa and Mt. Corchia can be identified not only by the occurrences of different petrographic types, but also by their different insoluble residue weight percentages (Isola Santa max average value=13.25 wt%; Arni, min. average value=6.09 wt%), occurrence of dolomite, Sr and P_2O_5 contents (respectively higher in marbles from Isola Santa and Mt. Corchia) and Sr isotopic ratios (0.70764-0.71620), which separate Arni from the other two districts (Negri Arnoldi *et al.*, 1999).

In Euboea, the lithotypes outcropping in the eastern (Karistos) and central (Brethela, Vatission) districts, with respect to those in the western district (Pyrgari, Styra sup., Styra inf.) reveal constantly saccaroid structure, lower insoluble residue (average 7.91 wt%), contents of Ni (average 20.63 ppm), Cr (average 23.69 ppm), Sr (average 700 ppm) and Ba (average 109.63 ppm), greater contents of Zr (average 20.75 ppm) and Rb (average 20.57 ppm) and values for both δ^{13}C-PDB (average 1.77‰) and the ^{87}Sr/^{86}Sr ratio (average 0.70772; Lazzarini *et al.*, 1995; Negri Arnoldi *et al.*, 1999).

Chlorite is practically lacking in the Karistos marble, and was identified in only one sample (KII 1) from the KII quarry located above the village of Mili (Ginnetti, A.A. 1992/1993, unpublished thesis). With respect to those of central Euboea, Fe_2O_3 (max. average 1.02 wt%) and Ba (max. average 129.63 ppm) are generally higher in the Karistos marble (Lazzarini *et al.*, 1995).

In western Euboea, Pyrgari is distinguishable from Styra sup. and Styra inf. by its Sr (average 880 ppm) and Ba (average 163 ppm) contents and higher C isotopic ratios (δ^{13}C - PDB = average 2.21‰; Negri Arnoldi *et al.*, 1999).

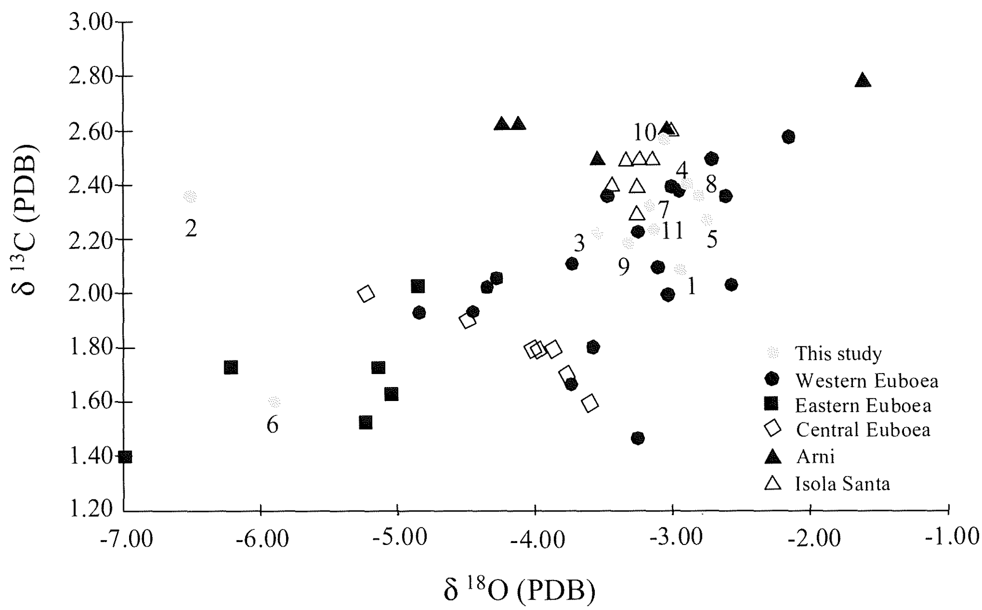

Fig. 2 – δ^{13}C/δ^{18}O plot of *«Cipollino verde»* marble of 11 samples, Apuan Alps (only dolomite-free samples) and Euboea. Diagram based on data from Negri Arnoldi et al., (1999).

With respect to the western sectors, Styra inf. has the lowest amounts of C ($\delta^{13}C$-PDB =average 1.97‰), Sr ($^{87}Sr/^{86}Sr$ = average 0.70779) and O ($\delta^{18}O$-PDB =average -3.77‰). In addition the marble has more Cr (average 76 ppm) and V (average 26 ppm) (Barbieri *et al.*, 1996; Negri Arnoldi *et al.*, 1999).

Considering Figs. 2, 3 and 4, which plot Apuan and Euboean marble values (Negri Arnoldi *et al.*, 1999) (except for dolomitic lithotypes from Mt. Corchia and Arni), the studied samples mainly fall in the western Euboea sector. Only C6 falls in the eastern one; C7 and C10 have values similar to those of Arni and Isola Santa (Apuan sector), and C2 does not fall in the typical fields of either region.

Considering the Al_2O_3/Y ratio (Fig. 3), the Apuan Alps may be excluded as the provenance of sample C7, whereas the Arni sector remains possible for C6. Samples C9 and C6 fall respectively in the eastern and western Euboea sector as regards their $\delta^{13}C$ and $\delta^{18}O$ isotopic ratios; C2 has very low values and Al_2O_3 plots outside.

Sample C10 definitely plots in the Apuan domain (Arni sector) if the $\delta^{13}C/(^{87}Sr/^{86}Sr)$ ratio is considered. Samples C1, C3, C4, C5, C7, C8 and C11 fall in the western Euboea field; in particular, the $\delta^{13}C$ values for C4, C7 and C8 are so high that Styra inf. may be rejected. Lastly, the low Sr contents of samples C4, C7 and C8 mean that the Styra inf. sector may be rejected (Tab. 4). The fact that sample C2 does not come from either region is confirmed. The $\delta^{13}C$, $\delta^{18}O$, Al_2O_3 and Y values of samples C6 and C9 (Figs. 2, 3 and 4), sometimes contradictory as regards sector of provenance, may be ascribed to Euboea, since their $\delta^{13}C/(^{87}Sr/^{86}Sr)$ ratios do not plot in any of the sectors. In fact, both samples have $^{87}Sr/^{86}Sr$ values higher than Euboean ones, and cannot be compared with central or eastern Euboean lithotypes (saccaroid structure) due to their petrographic features – nor, in particular, with Karistos

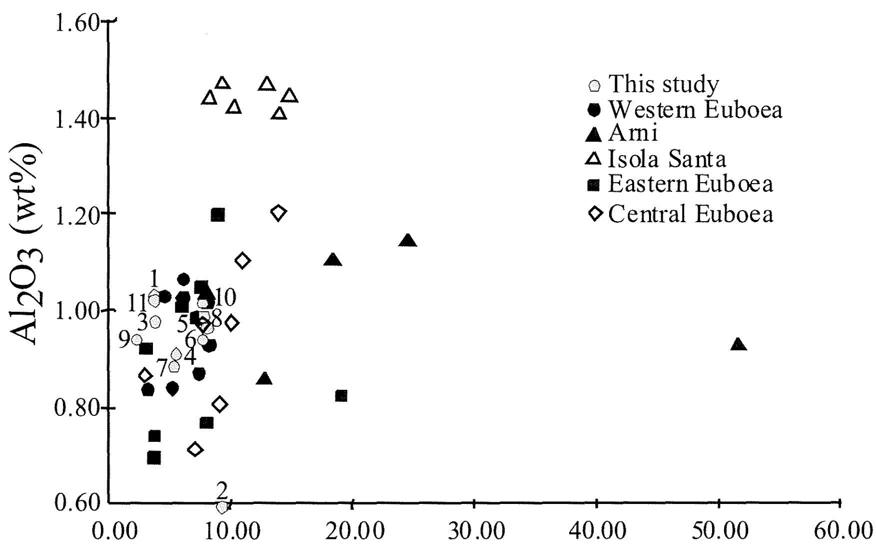

Fig. 3 – Plot of Al_2O_3/Y contents in *«Cipollino verde»* of 11 samples, Apuan Alps (only dolomite-free samples) and southern Euboea. Contents normalised to 5 wt% of I.R. (see text). Euboean data from Negri Arnoldi et al. (1999).

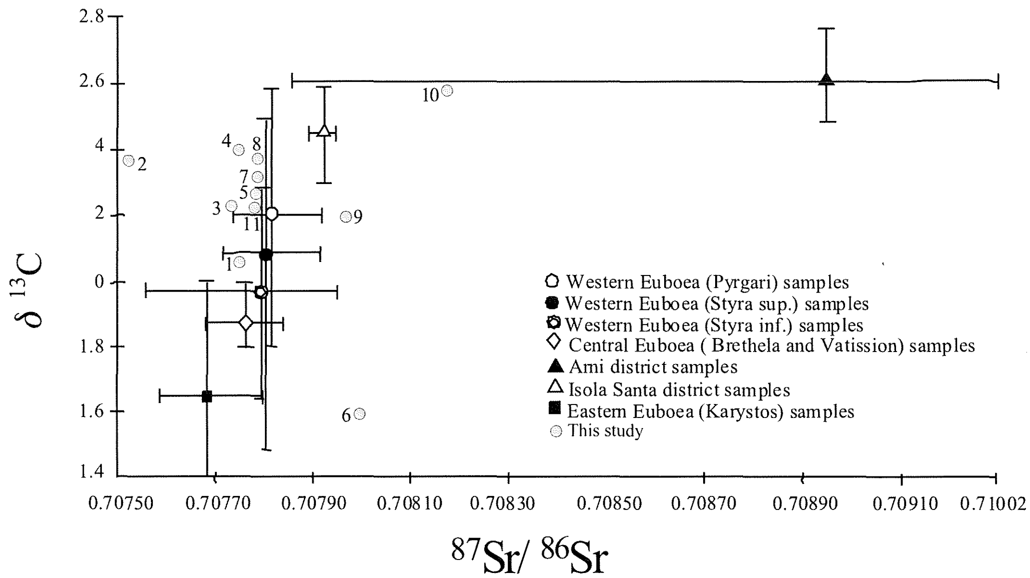

Fig. 4 - ($^{87}Sr/^{86}Sr$)/$\delta^{13}C$ plot of «*Cipollino verde*» marble of 11 samples from Apuan Alps (only dolomite-free samples) and southern Euboea. Diagram based on data from Negri Arnoldi et al. (1999).

types, because of abundant chlorite among the phyllosilicates. For sample C6, the Styra sup. sector is rejected due to the C, O and Sr isotopic values (Figs. 2, 4); Pyrgari and Styra inf. are also excluded because of low Sr and Ba (Tab. 2). For sample C9, none of the Euboean districts can be taken into account, due to high Al_2O_3, Ba, and low Sr, Ni, and La (Tab. 2; Barbieri *et al.*, 1996).

Conclusions

The eleven samples of «*Cipollino verde*» marble from grooved standing columns and shafts (lying on the ground) from the *Portico degli Dei Consenti* (Roman Forum, Rome, Italy) were subdivided, on the basis of their insoluble residue content, into two groups: i) high contents (10.84-28.34 wt%) and ii) low contents (5.76-8.96 wt%).

With the exception of samples C2, C4 and C8, which have saccaroid structure with greenish, sub-parallel to slightly wavy stripes, the other samples have a granoblastic-heteroblastic (foliated lithotypes) fabric, and oriented texture evidenced by folded bands of more or less abundant phyllosilicates. All the samples are lack dolomite. On the basis of paragenesis, all samples may be ascribed to the greenschist facies.

Chemically, samples C1, C3, C4, C5, C7, C8, and C11 have good compositional homogeneity and similar isotopic values, suggesting that they belong to a single population deriving from a common geological environment. Samples C2, C6, C9 and C10 have different geological origin, as shown by some oxide and/or element ratios of the non-carbonate fraction and their $^{87}Sr/^{86}Sr$ ratio values.

After comparisons with the dolomite-free Apuan (Arni, Isola Santa, Mt. Corchia) and Euboean sectors (Karistos, Brethela, Vatission, Pyrgari, Styra sup., Styra inf.), the «*Cipollino verde*» marble samples (C1, C3, C4, C5, C7, columns raised from the ground, and C8 and C11, lying columns) were ascribed to the Euboean domain, taking into account $\delta^{13}C/\delta^{18}O$, Al_2O_3/Y and $\delta^{13}C/(^{87}Sr/^{86}Sr)$ values. In particular, C4, C7 and C8 plot in a field nearer the Styra sup. sector, and the others in a common field between Styra sup. and Styra inf.

Sample C10 (lying column) plots among the Apuan marble (Arni sector), whereas samples C2, C6 (raised columns) and C9 (lying column) cannot come from either Apuan or Euboean quarries.

Archaeometric results indicate the same provenance for most of the «*Cipollino verde*» samples, except for marble from two columns raised from the ground and two shafts lying near the colonnade. For the latter, it may be hypothesised that either the materials were chosen because of their similarity to the original and larger stock (marble stock-piled according to lithotype, in *stationes marmorum* near Karistos and the ancient port of Ostia) or that the columns came from another monument and were re-worked at the moment of their re-use. For the so-called «Karistian» marble, analyses confirmed the possibility of identifying the exact location of the quarry. Together with an inventory and further study of the blocks and handworked pieces still remaining in the quarries, we will be able to reconstruct the history of the use of «*Cipollino*» marble.

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